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AMXFC REPORT NO. 39-62

ADAPTABILITY OF SHEAR PRESSES TO SPECIFYING TENDERNESS OF COOKED, SLICED, FREEZE-DRIED BEEF

Interim Report
December 1962

ARMED FORCES FOOD AND CONTAINER INSTITUTE
U. S. ARMY QM RESEARCH AND ENGINEERING COMMAND
CHICAGO 9, ILLINOIS

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QM Food & Container Institute for the Armed Forces, QM Research & Engineering Command, U. S. Army, Chicago 9, QMFCIAF Rpt. No. 39-62

Date Dec 1962 Proj. No 7-84-06-032

pp 17 tbl 5 fig. 2

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Primary Field: Freeze-dehydration

Secondary Field(s): Animal Products

UNCLASSIFIED

1. Freeze-drying
2. Beef

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Development

Adaptability of Shear Presses to Specifying Tenderness of Cooked, Sliced, Freeze-Dried Beef

Interim Report

by

J. M. Tuomy and R. G. Young

Meat Products Branch

Food Division

December 1962

Armed Forces Food and Container Institute

Adaptability of Shear Presses to Specifying Tenderness of Cooked, Sliced, Freeze-Dried Beef

Summary

A series of runs were made in which the tenderness and cuttability of cooked sliced beef as rated by a trained technological panel were compared to the ratings obtained with both the Warner-Bratzler and the Kramer shear presses. The correlations found between the various ratings were good and it is believed that the shear press readings can be developed into requirements for freeze-dried meats which would increase assurance of procuring satisfactory end products. Differences of product slice thickness from one-eighth to one-fourth inch were found not to make an appreciable difference in the final ratings by either the panel or the presses provided that the slices could be combined to give the same height stack for the shear press.

Adaptability of Shear Presses to
Specifying Tenderness of Cooked,
Sliced, Freeze-Dried Beef

One of the most important goals in the development of the requirements in subsistence specifications is the stating of the requirements in objective terms on the end product. With a great many quality attributes this has not been too difficult. As of now, however, there are no completely satisfactory methods for specifying objectively the various organoleptic characteristics of food. Probably the most important organoleptic characteristic as far as meat is concerned is tenderness. The study herein reported is concerned with the use of shear presses in objective determination of tenderness and is part of a larger study in the organoleptic properties of freeze-dried meats and the development of objective tests for measuring them.

Several mechanical methods for the determination of meat tenderness have been studied at various times Shear presses have received the most attention Two presses most commonly mentioned in the literature are the Warner-Bratzler (1) and the Kramer (2).

The Warner-Bratzler shear press has been in use for many years although results reported in the literature on its validity are somewhat at variance. For example, Klose _et al_. (3) found close agreement between organoleptic tests and the Warner-Bratzler while working on turkey. On the other hand, Hurwicz and Tischer (4) recommended that the instrument be redesigned to improve its reliability after they had studied the instrument using wax to provide chemical homogeneity.

Several modifications have been suggested such as using a strain-gage rather than the customary spring scale (5). However, the unmodified instrument is still used to a great extent. It is an inexpensive instrument that is quite widely available and which is simple enough that non-technical personnel can be trained in its use in a few minutes.

Previous studies in this series (6, 7) have utilized the Kramer shear press and technological panels in studying texture effects. Very good correlations of the Kramer to the panel have been obtained particularly with the panel evaluation of "cuttability." Correlations with "tenderness" have been good, but ordinarily slightly less than those with "cuttability." Results have indicated that the Kramer shear press has distinct possibilities for use in specifying requirements for freeze-dried meats provided that the methodology is very carefully standardized. The basic disadvantages of the Kramer at the present time for specification use are its relative high cost and its limited availability at present throughout the meat industry.

The purpose of this study is to compare the results of the Warner-Bratzler shear press, the Kramer shear press, and a technological panel under controlled conditions. Two slice thicknesses of cooked, sliced freeze-dehydrated beef are used which approximate slices contemplated for use in the Quick-Serve meals. However, results are not expected to be directly applicable to specification requirements for tenderness since much more work would be needed to develop methodology and to set limits which would be in line with consumer preferences.

Experimental Methods

The meat used in this study was the semi-membranosus muscle of canner/cutter grade beef. The meat was received fresh, the muscle removed, then frozen. For cooking, the muscle was air defrosted and then stuffed into spring loaded forms four by four inches in cross section.

The meat was cooked in a retort using the same procedure as used in an early study in this series (6). In order to obtain a range of tenderness values, cooking times of 45, 75, 120, and 180 minutes were used. Steam pressure was 10 pounds per square inch gage. After cooking, the springs in the molds were reset and the meat chilled overnight. The chilled meat was sliced one-half and one-fourth inch thick. All slices were trimmed free from excess fat, gristle, and similar material which might interfere with or distort the evaluations. The slices were frozen in trays and freeze-dehydrated at 750 microns and 110°F. plate temperature for 18 hours using conduction heating.

For evaluation purposes, the slices were rehydrated for 20 minutes in 140°F. water. Panel evaluations were accomplished by a 10 member technological panel rating the product on nine-point scales for "tenderness" and "cuttability." The scales ranged from "extremely tough" -- 1, to "extremely tender" -- 9.

For shear press evaluations the slices were cut into one inch squares. For the Warner-Bratzler, the squares were stacked to a three-fourth-inch height and the stack sheared. For the Kramer press, three one-fourth-inch stacks were placed side by side in the cell. A downstroke of 30 seconds and a 3000 pound ring were used with the Kramer.

Three replications were run for each sample with each press and the results reported as an average. For both presses the peak values were read.

The experiment was so designed that sufficient quantities of one-eighth and one-fourth inch slices were obtained from a single muscle to make complete evaluations on the muscle with the panel, Warner-Bratzler, and Kramer.

Results and Discussion

Mean scores for the various measurements are shown in Table 1. Each mean measurement shown is the average from eight separate runs. A total of 32 muscles were used in the study. Thus, each individual figure including the combined figures shown in the table is the average of results on eight muscles. Since three measurements were made on each muscle with both shear presses at both thicknesses, the combined figures represent 48 individual Kramer or Warner-Bratzler measurements.

Correlations between measurements are shown in Table 2. From these correlations it can be seen that the Warner-Bratzler shear press gave results comparable to those obtained with Kramer shear press. Furthermore, the correlations of the presses to the organoleptic ratings were sufficiently high to indicate that both presses have possibilities for use in specifications. It should be noted that these correlations are based on pairing of measurements within the same beef round. A preliminary study indicated much poorer correlations when the pairing of measurements was on muscles from different rounds. The wide difference in tenderness found in meat of the same grade has been noted in all of the previous studies in this series.

It would seem logical that different slice thicknesses would produce different organoleptic tenderness results. On the other hand, it would seem that the shear presses would indicate the same tenderness in a given sample no matter what the slice thickness provided that the same height stack was tested. The latter was found to be true but the former was found to be erroneous as indicated in Table 1. From a specification standpoint, then, limits could be based on one set of shear press values for a given product even if it is sliced to different thicknesses provided that a stack of slices could be made up to the same height each time for testing.

Although the correlations as shown in Table 2 are considered good, they indicate that single sample measurements would not be definitive enough for specification use. For example, the correlations shown for the Warner-Bratzler against the panel tenderness is -.860. This means that $.860^2$ or only about 74 percent of the measurements could be said to correlate and 26 percent did not. Therefore, it was decided to analyze the data to determine what accuracy could be expected under specification conditions if different numbers of samples were taken from the same lot.

The linear relationships between the four measures of tenderness determined by the method of least squares and the measure of the precision of estimates (Sx_2x_1) are shown in Table 3. Sixty-four samples are used as the basis for the calculations. Since it had been determined that there was no significant difference between the results expected whether the beef was sliced one-fourth or one-eighth inch thick, the data for the two thicknesses was combined. The standard errors ($Sx_2\ x_1$) are a measure of the variation about the linear regression line. It is the variation in the dependent variable (X_2) after its regression on X_1 has been discounted. Theoretically, as the sample size is increased, the size of Sx_2x_1 should decrease as a function of $\sqrt{\frac{1}{n}}$. For the situation of four samples, then the (Sx_2x_1) should be one-half that for one sample when the true relationship is a linear one. In Table 3, for sample size four, the values of ($Sx_2\ x_1$) are roughly one-half that of sample size one.

Table 4 and Figure 1 show the probabilities of acceptance by Kramer shear values at determined tenderness levels. Table 5 and Figure 2 show the same thing for the Warner-Bratzler shear values. Figures 1 and 2 are so plotted that they are very similar to the operating characteristic curves for sampling plans in MIL-Std-105, Sampling Procedures and Tables for Inspection by Attributes (8), and can be interpreted in much the same way. Arbitrarily, the upper limits (4) for the shear values were selected such that the probability [P(a)] that the shear value determined from a sample of specified tenderness will exceed U is equal to 90 percent for a panel tenderness of 5.0.

Examination of Figure 1 and 2 indicates that sampling plans for shear presses could be devised which would provide assurance of freeze-dried meat complying with desired tenderness characteristics. These plans would be compatible with plans already in use with subsistence procurements.

It is evident from the above that it will be possible to work out methods for using both the Kramer and Warner-Bratzler shear values as tenderness criteria in freeze-dried meat specifications. However, methodology and sampling plans will have to be worked out very carefully since any one reading from either machine cannot be considered as an absolute objective measurement. Furthermore, throughout this study, the technological panel ratings have been treated as absolute objective measurements which they are not, even though reproducibility with a trained panel is considered excellent.

Conclusions

The specifying of either the Kramer shear press or the Warner-Bratzler shear press or both for cooked, freeze-dried meat is feasible. However, further work is necessary in order to standardize methodology, work out Acceptance Quality Levels, and devise sampling plans for each product. Although the correlations between shear presses and technological panel were found to be good, single measurements could vary enough to lead to completely erroneous conclusions. Therefore, statistical sampling plans and provisions for discarding "wild" readings by statistical means will have to be devised.

Under the conditions of this study, slice thicknesses in the range of one-eighth to one-fourth inch do not make an appreciable difference in the tenderness ratings given the meat by a trained panel. In addition, shear press limits can be set which are applicable to different slice thicknesses of the same product provided that the slices can be stacked to the same height.

Acknowledgement

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Table 1

Table of Means

Comparison of Tenderness Measurements

Method	Cook time (min)	Thickness 1/4 inch	1/8 inch	Combined
Kramer	45	525	578	552
	75	500	516	508
	120	371	349	360
	180	237	281	259
Bratzler	45	26.4	25.8	26.1
	75	24.2	24.0	24.1
	120	18.2	15.9	17.1
	180	8.9	9.4	9.2
Tenderness (panel)	45	4.0	4.4	4.2
	75	4.7	4.8	4.8
	120	5.5	6.1	5.8
	180	6.9	6.4	6.7
Cuttability (panel)	45	4.1	4.7	4.4
	75	5.0	5.3	5.2
	120	6.2	7.2	6.7
	180	8.1	7.8	8.0

Table 2

Correlations Between Measurements

	1/4 inch	1/8 inch
Kramer - Tenderness (panel)	-.842	-.823
Bratzler - Tenderness (panel)	-.860	-.844
Kramer - Bratzler	.868	.898
Cuttability - Tenderness (panel)	.964	.886

Table 3

Estimate of Precision for Differing Numbers of Samples

Relationship	Correlation - Single Sample	Equation	Sx_2x_1 for number of samples 1	2	4
Kramer - Tenderness	-.787	K=1025-112.89T	99	80	50
Bratzler - Tenderness	-.852	B=52.1- 6.17T	4.23	3.14	2.26
Kramer - Cuttability	-.760	K=905- 80.91C	104	83	59
Bratzler - Cuttability	-.866	B=46.9- 4.65C	4.04	3.00	2.04
Bratzler - Kramer	.862	B=0.75+.0435K	4.08		
Cuttability - Tenderness	937	C=-.77+1.26T	0.530		

Table 4

Probability of Acceptance by Kramer Shear Values at Determined Tenderness Levels

		No. Samples (U)	1 588		2 563		4 525	
X_1	X_2		z	P(a)	z	P(a)	z	P(a)
7.0	234		3.58		4.11		5.82	
6.5	291		3.00	99.9	3.40		4.68	
6.0	348		2.42	99.2	2.69	99.6	3.54	
5.5	404		1.86	96.9	1.99	97.7	2.42	99.2
5.0	461		1.28	90	1.28	90	1.28	90
4.5	517		0.72	76	0.58	72	0.16	56
4.0	573		0.15	56	-0.12	45	-0.96	17
3.5	630		-0.42	34	-0.84	20	-2.10	2
3.0	686		-0.99	16	-1.54	6	-3.22	
2.5	743		-1.57	6	-2.25	1	-4.36	
		$S_{X_2 \cdot X_1}$	99		80		50	

(Upper limits (u) for shear values so selected that P (a)= 90 percent for a panel tenderness of 5.0.)

U = upper limit for shear value that is acceptable

X_2 = expected shear value at specified tenderness level, X_1.

$z = (U - X_2) / S_{X_2 \cdot X_1}$

P(a) = probability (in percent) that shear value determined from a sample of specified tenderness will exceed U.

$S_{X_2 \cdot X_1}$ = standard error of estimate determined from the indicated number of samples combined into a mean.

Table 5

Probability of Acceptance by Warner-Bratzler Shear Values at Determined Tenderness Levels

	No. Samples (U)	1 26.6		2 25.2		4 24.1	
X_1	X_2	z	P(a)	z	P(a)	z	P(a)
7.0	8.9	4.18		5.19		6.72	
6.5	12.0	3.45		4.20		5.35	
6.0	15.1	2.72	99.7	3.22	99.9	3.98	
5.5	18.2	1.99	97.7	2.23	98.7	2.61	99.5
5.0	21.2	1.28	90	1.28	90	1.28	90
4.5	24.3	0.54	71	0.29	61	-0.09	46
4.0	27.4	0.19	42	-0.71	24	-1.46	7
3.5	30.5	-0.92	18	-1.69	5	-2.83	
3.0	33.6	-1.65	5	-2.68		-4.20	
2.5	36.7	-2.39	1	-3.66		-5.58	
	$S_{X_2 \cdot X_1}$	4.23		3.14		2.26	

(Upper limits (u) for shear values so selected that P(a)= 90 percent for a panel tenderness of 5.0).

U = upper limit for shear value that is acceptable.

X_2 = expected shear value at specified tenderness level X_1.

$z = (U - X_2) / S_{X_2 \cdot X_1}$

P(a) = probability (in percent) that shear value determined from a sample of specified tenderness will exceed U.

$S_{X_2 \cdot X_1}$ = standard error of estimate determined from the indicated number pf samples combined into a mean.

Figure 1

Probability of Acceptance by Kramer Shear Values at Determined Tenderness Levels

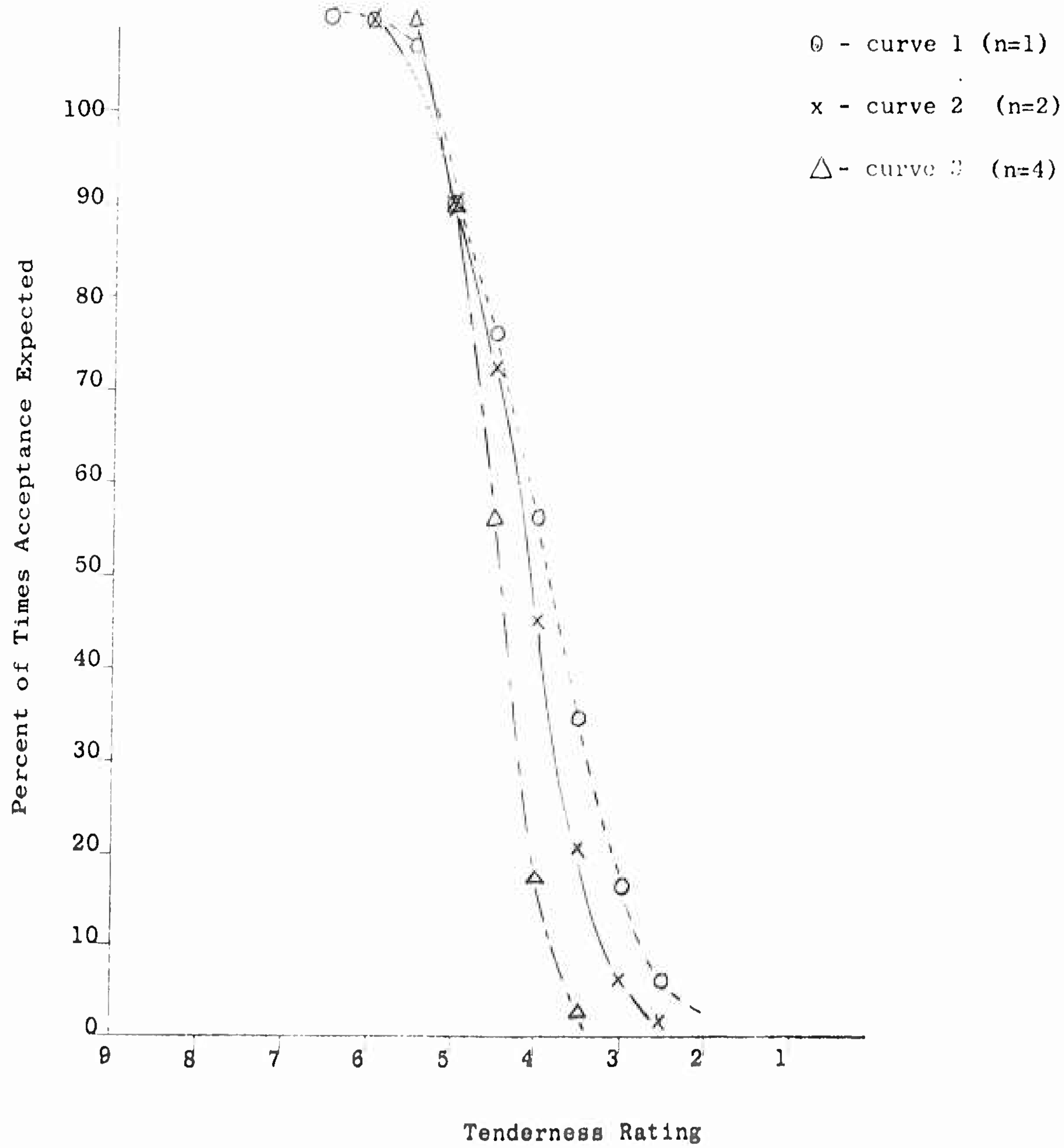
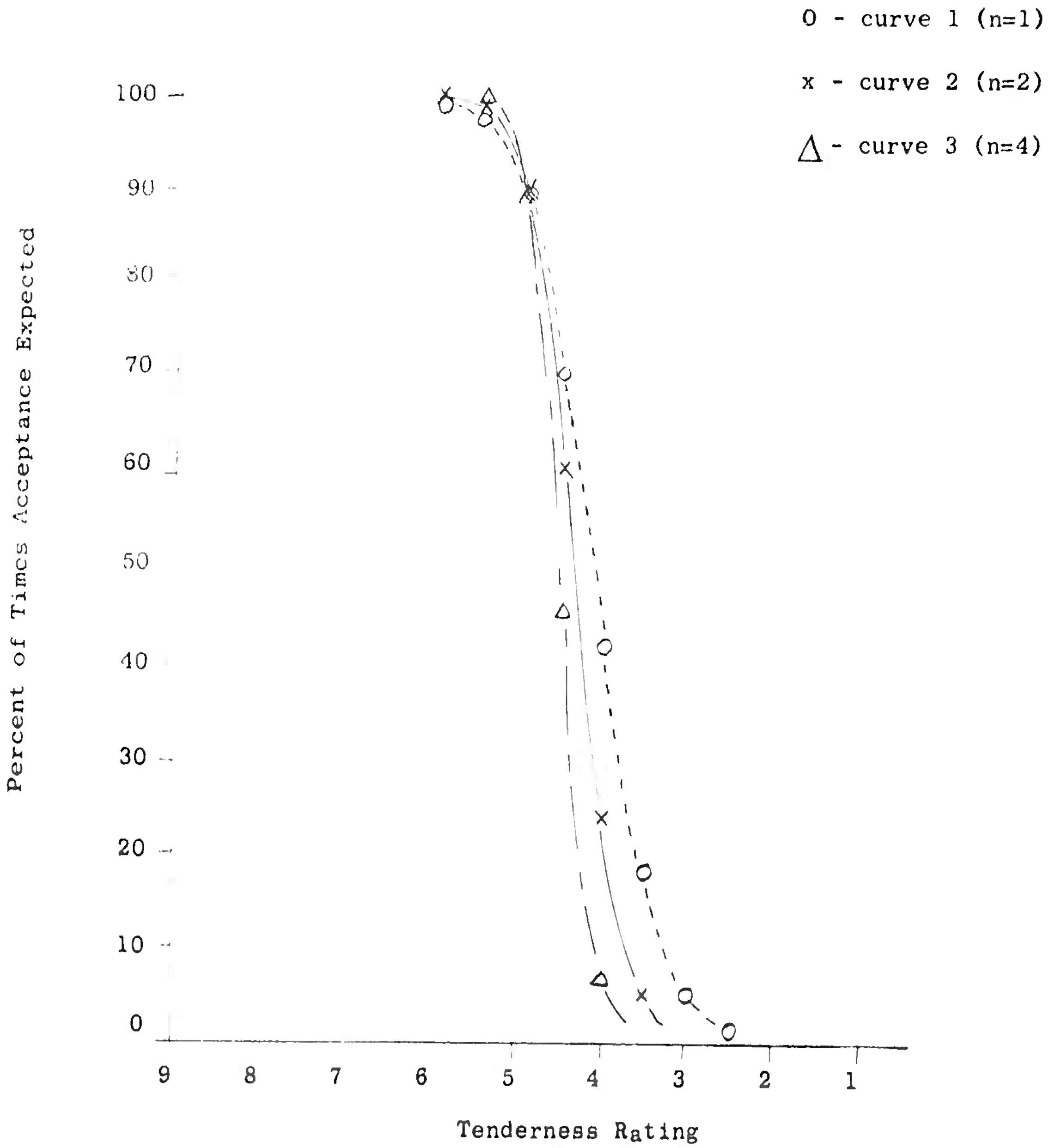


Figure 2

Probability of Acceptance by Warner-Bratzler Shear Values at Determined Tenderness Values



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